chapter 2

the new dynamics of the Massachusetts knowledge-based economy

Since the Industrial Revolution of the early nineteenth century, two or three large manufacturing industries determined the economic well-being of the Commonwealth. These were our export industries – first textiles, shoes, and machinery, then defense, electronics, and computers. Because they sold goods beyond our borders, they generated the income needed to import food, fuel, and manufactured goods produced in other states and overseas. When exports boomed, so did the rest of the Commonwealth. The expansion of employment and income in these export industries boosted demand for medical care, housing, restaurant meals, and all other goods and services produced for the local Massachusetts market.

In the new knowledge-based economy, the competitive success of our export sector remains critical to our economic well-being. We must still export to pay for our imports. And the performance of our export sector continues to be the key engine driving the overall economy. What has changed is the composition of that export sector and the nature of the competitive marketplace in which it operates.

The share of Massachusetts employment in manufacturing – our specialty for nearly two hundred years – actually fell below the national average during the downturn of the early 1990s. Manufacturing employment in Massachusetts continues to fall and now stands nearly a percent point below the national norm. Aside from the bulge in the catch-all services sector, the Commonwealth's industrial composition at the dawn of the twenty-first century looks much like that of the nation as a whole (see Figure 2-1).

The New Massachusetts Export Sector

What best distinguishes the Commonwealth's export sector today is its reliance on a highly educated workforce. The high educational attainment of the Massachusetts workforce – and the gap separating the Commonwealth from the rest of the nation – is relatively new, and has developed over the past quarter century. This distinctive educational profile emerged, moreover, in response to the growth of export industries that employ large numbers of college-educated workers (see Figure 2-2).[1]

Before 1970, the overwhelming majority of educated workers were employed in industries that catered to local markets. They were teachers, doctors, nurses, lawyers, accountants, and clergy in what can be termed the "old professional sector." The

[1] Lynn E. Browne and Steven Sass, "The Transition from a Mill-based to a Knowledge-based Economy: New England, 1940-2000," Peter Temin, ed., *Engines of Enterprise: An Economic History of New England*. (Cambridge: Harvard University Press, 2000); Yolanda K. Kodrzycki, "New England's Educational Advantage: Past Successes and Future Prospects," Federal Reserve Bank of Boston *New England Economic Review*, January/February 2000, and "Migration of Recent College Graduates: Evidence from the National Longitudinal Survey of Youth," Federal Reserve Bank of Boston *New England Economic Review*, January/February 2001.

Commonwealth's great universities did attract large numbers of out-of-state students and produced a disproportionate number of graduates with baccalaureate, graduate, and professional degrees. But our economy offered them few attractive job opportunities and most of these people soon left the State to find employment.[2]

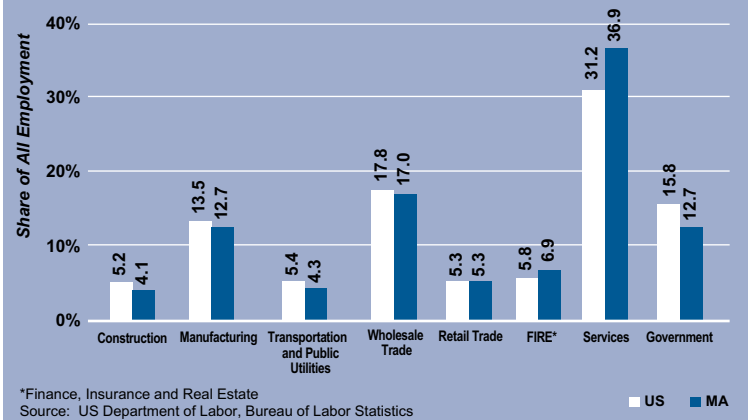
Since 1970, however, new professional-intensive industries and activities emerged that did not need to be geographically close to their customers. There were two critical factors:

- **Advances in the economic value of a college education due to…**
  – Improvements in the skills developed and transmitted at colleges and universities. This can be seen in our improved ability to deliver high quality medical care, manage marketing campaigns and investment portfolios, design buildings, and develop pharmaceuticals and IT systems.
  – The development of production technologies that diminished the relative value of craft skill and manual labor vis-à-vis professional design, engineering, and managerial work.
  – The explosive growth of information technologies that augment professional and managerial skills, while reducing the need for administrative and clerical labor.
- **Advances in electronic communications and air transportation** that significantly reduced the cost of moving ideas, people, and products around the globe.

In the 1990s, knowledge-based export activities grew to such an extent that today they clearly dominate the Massachusetts export sector. No two or three large, well-defined knowledge-based industries dominate our exports. Instead, there are *clusters* of firms, competing globally, in the most sophisticated branches of many different industries.[3] Massachusetts, for example, has a disproportionate share of employment in higher education. The most critical factor, however, is that the Commonwealth is home to many of the world's elite universities and teaching hospitals. We are also home to a large securities industry. But what's key is our concentration of firms providing high-value investment management and IT systems development. Massachusetts specializes in management consulting. But what distinguishes our State is the disproportionate number of firms providing services to the world's largest and most demanding corporate clients. The common denominator linking most of our export clusters is their reliance on large numbers of highly educated knowledge workers (see sidebar, *The Massachusetts Export Sector, on next page*).

figure 2–1

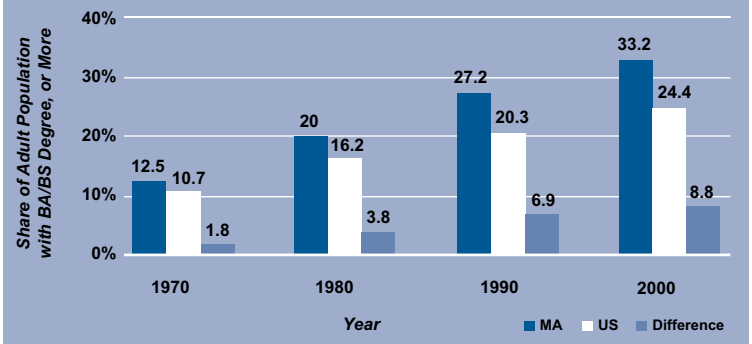
Aside from more jobs in services, our current industrial structure looks much like the nation…



*Finance, Insurance and Real Estate
Source: US Department of Labor, Bureau of Labor Statistics

figure 2–2

…yet there is distinctive educational attainment in Massachusetts



Source: Y Kodrzycki, "New England's Educational Advantage," New England Economic Review, January/February 2000

[2] Steven Sass, "The U.S. Professional Sector: 1950-1988," *Federal Reserve Bank of Boston New England Economic Review,* January-February 1990.

[3] For the importance of industry clusters, see the sidebar, *Michael Porter's "Cluster Theory of Competitiveness,"* in Chapter 1.

The Massachusetts Export Sector

Professor Michael Porter, in his influential study *The Competitive Advantage of Massachusetts*, organized the Massachusetts export sector into four broad industry clusters. These were "substantial clusters of industries which compete nationally and internationally, have the size, sophistication, productivity, and national and international positions to drive economic upgrading. These clusters include both manufacturing and service industries which are often closely interconnected."[4] The four were:

- **Financial Services** (see figure 2-3)
- **Health Care** (see figure 2-4)
- **Information Technology** (see figure 2-5)
- **Knowledge Creation** (see figure 2-6)

Each cluster includes industries that cater primarily to local Massachusetts markets. Industries such as banking in Financial Services and health care services in Health Care recieve the bulk of their revenues from within the Commonwealth. Porter's notion, however, is that the competitiveness of export markets depends on the vitality of these clusters of closely related industries that share technologies, skilled workers, and specialized suppliers. Thus, local markets leverage skills that enable upgrading and export outside the State.

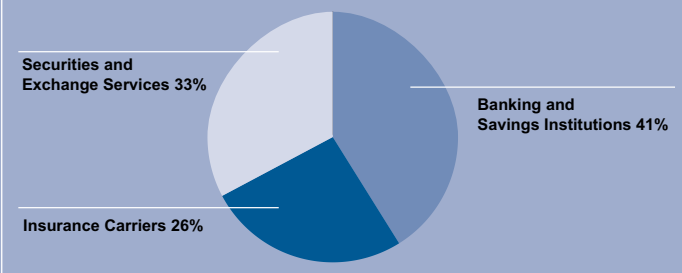
To provide a fuller picture of the Commonwealth's export sector, *Choosing to Compete*,[5] the Commonwealth's economic strategy document, added tourism and the manufacturing industries not included in Porter's four large clusters. Professors Robert Forrant, Philip Moss, and Chris Tilly, of UMass-Lowell built upon this format and focused on these six broadly defined clusters in their recent study *Knowledge Sector Powerhouse*.[6] They added:

- **Traditional Manufacturing**, including all manufacturing, except industries found in other export clusters, such as computer and related hardware manufacturing, scientific instruments, and medical instruments. The cluster includes paper, rubber and plastics, fabricated metals, apparel and textiles, and industrial machinery (see figure 2-7). Many industries in the cluster are relatively mature, generally serving markets with slower growth prospects than the other export clusters. However, traditional manufacturers continue to provide a foundation for regional economies in Massachusetts. Many firms in the cluster also continue to thrive in the Commonwealth by applying advanced technology to enhance productivity.[7]
- **Travel and Tourism**, which includes hotels, lodging places, restaurants, attractions, and transport facilities for business and leisure travlers. To get a clearer measure of export activity in the cluster, we use the data on "hotels and lodging places" industry as a proxy for the larger Travel and Tourism Cluster, in Part II.

These additional clusters are clearly part of the Commonwealth's export sector. While Travel and Tourism and Traditional Manufacturing are not so clearly "knowledge-based," they increasingly rely on technical and managerial expertise to remain competitive in the national and global marketplace.[8] The six clusters examined in *Knowledge Sector Powerhouse* inform the economic analysis of the seven regions of the Commonwealth presented in Part II.

figure 2–3

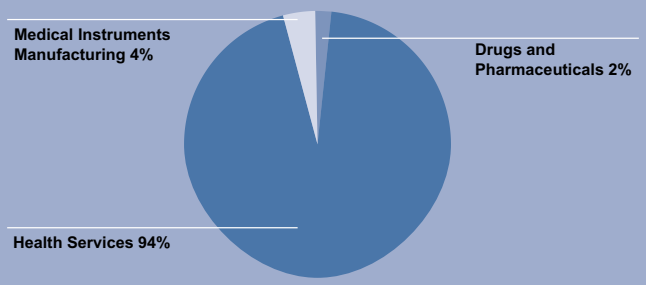
Financial Services Employment, 2000
Cluster Employment = 166,742



Source: Massachusetts Division of Employment and Training

figure 2–4

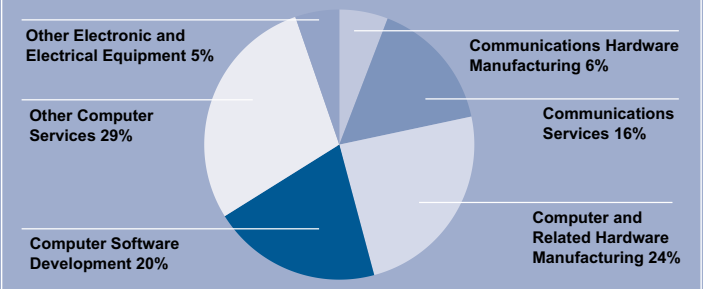
Health Care Employment, 2000
Cluster Employment = 359,899



Source: Massachusetts Division of Employment and Training

figure 2–5

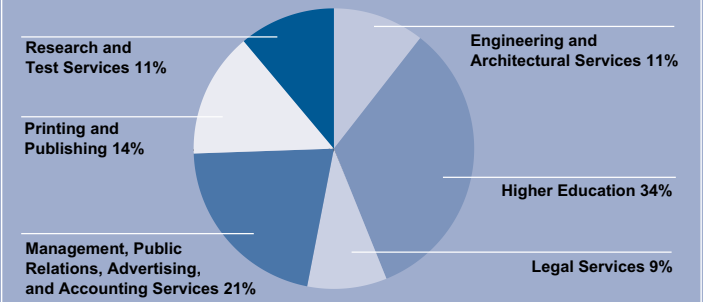
Information Technology Employment, 2000
Cluster Employment = 277,392



Source: Massachusetts Division of Employment and Training

figure 2–6

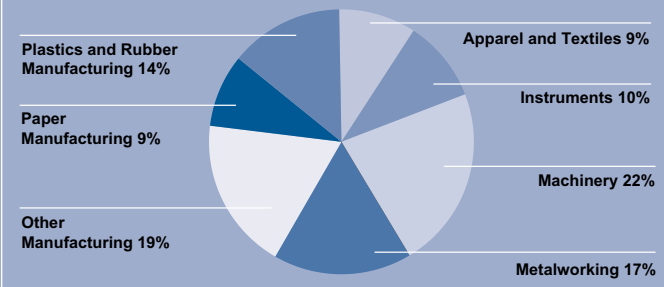
Knowledge Creation Employment, 2000
Cluster Employment = 328,305



Source: Massachusetts Division of Employment and Training

figure 2–7

Traditional Manufacturing Employment, 2000
Cluster Employment = 135,358



Source: Massachusetts Division of Employment and Training

Another University of Massachusetts study provides a different view of the Massachusetts export sector.[9] Using the new North American Industrial Classification System (NAICS), which provides greater detail on service industries than the traditional Standard Industrial Classification (SIC) system, it identified industries that employ a disproportionate number of workers in the Commonwealth. They calculate "location quotients" – the industry's share of State employment as a ratio of its share of U.S. employment – for key NAICS industries, for Massachusetts, and key competitor states. Industries with high location quotients employ disproportionately large numbers of workers and generally are involved in production for export.

figure 2–8

Location Quotients for Selected Sectors and Competitor States

NAICS Sector	Description	MA	CA	CO	NJ	NY	TX	All Other
21	Mining	0.08	0.39	1.50	0.12	0.12	3.01	1.36
23	Construction	0.71	0.90	1.37	0.80	0.74	1.09	1.02
31	Manufacturing	0.92	0.97	0.64	0.76	0.71	0.83	1.14
334	Computer and electronic product manufacturing	2.34	2.13	1.49	0.73	0.78	1.17	0.70
48	Transportation and warehousing	0.67	0.98	0.81	1.42	0.91	1.04	1.00
51	Information	1.39	1.33	1.54	1.36	1.43	1.00	0.84
514	Information services and data processing services	1.50	0.88	1.40	0.83	1.73	1.27	0.96
52	Finance and insurance	1.36	0.96	0.92	1.13	1.60	0.88	0.93
523	Securities, commodity contracts, other financial investments, and related activities	2.90	0.96	1.08	1.81	4.06	0.64	0.57
54	Professional, scientific, and technical services	1.31	1.39	1.23	1.31	1.27	0.97	0.83
61	Educational services	1.48	1.34	1.49	1.48	1.38	1.01	0.79
62	Health Care and social assistance	1.24	0.83	0.81	0.93	1.27	0.95	1.03
71	Arts, entertainment, and recreation	0.85	1.24	1.40	0.73	1.14	0.78	0.95

The location quotient (LQ) represents an industry's share of Massachusetts employment, divided by an industry's share of national employment.LQ values exceeding 1.0 indicate an industry's above-average presence in Massachusetts. These industries also create products and services that exceed local demand and are exported.

Less than or equal to 80% of share of employment
120% to 200% of share of employment
200% to 300% of share of employment
300% plus share of employment

Source: Moore et al., "Science, Technology and Investment," University of Massachusetts Donahue Institute, 2001

[4] Michael Porter, *The Competitive Advantage of Nations* (New York: Free Press, 1990) and *The Competitive Advantage of Massachusetts* (Cambridge: MonitorCorporation, 1991).

[5] Massachusetts Executive Office of Economic Affairs and The University of Massachusetts, *Choosing to Compete* (Boston: Massachusetts Executive Office of Economic Affairs, 1993).

[6] Robert Forrant, Philip Moss, and Chris Tilly, *Knowledge Sector Powerhouse*, (Boston: Donahue Institute, University of Massachusetts, 2001). Like Forrant, et al., the authors of *Choosing to Compete* had identified tourism and these other manufacturing industries as part of the Massachusetts export base.
This report applies the name "Traditional Manufacturing" to the export industry cluster identified as "Other Manufacturing" in *Knowledge Sector Powerhouse.*

[7] Ibid,pg.30

[8] Unlike Porter's four original clusters, the two added in *Knowledge Sector Powerhouse* do not include industries that cater primarily to the local Massachusetts market. As "hotels and lodging places" is a proxy for the larger Tourism Industry, looking at its employment or revenues alone understates the significance of the larger Tourism Industry.

[9] Craig Moore, Susan Porter, and Vanitha Swaminathan, *Science, Technology and Investment: The Cycles of Growth in Massachusetts*, unpublished manuscript, UMass Donahue Institute, University of University of Massachusetts, 2001.

The Four Factors Critical to the Economic Development of the Commonwealth

In the 1990s, four factors emerged to define the innovative and competitive potential of the new Massachusetts economy. They are: the supply of knowledge workers; our capacity for networked entrepreneurship; the opportunities presented by globalization; and the challenge of maintaining the quality of life in our communities. These four factors will remain the key to our competitive strength and economic success as we move into the twenty-first century.

Factor 1: Knowledge Workers - While financial resources and physical infrastructure remain important, the quality of human capital in the Commonwealth is the key to our competitive success. The central role of knowledge workers explains several key characteristics of the Massachusetts economy:

Higher per capita income - Workers with similar educational profiles earn much the same wage in the Commonwealth as in the nation. The higher per capita incomes in Massachusetts can be explained by the educational composition of our workforce. This suggests that Massachusetts incomes can only grow, vis-à-vis the nation, if the educational attainment and knowledge-based skills of our workforce are enhanced.[10]

A high rate of worker mobility - The value contributed by highly educated workers is increasingly based on professional skills and relationships that can be taken from one firm to another. Such workers tend to use these skills on projects with a finite life cycle; typically five-to-ten years or less, rather than making a career-long commitment to a particular organization. What's most attractive to knowledge workers are opportunities to participate in innovative projects that promise great rewards, while enhancing their professional skills.

An abundance of small entrepreneurial companies - Small organizations, including semi-independent units of larger companies, offer highly educated workers far more opportunity to exercise their creativity and discretion – and this represents their major contribution to the "new economy."

Factor 2: Networked Entrepreneurship - Entrepreneurs mobilize resources by using various types of networks. These networks include formal professional, trade, and civic associations. Even more important are informal networks, such as business and professional relationships, occasional contacts such as hiring interviews, conversations at business meetings, and introductions at social events. Through these relationships, entrepreneurs access ideas, money, people, and markets.

Networked entrepreneurship is the process that energizes industry clusters. It connects firms with suppliers, customers, academics, government agencies, partners, and even competitors. It can mobilize resources far faster than impersonal market relationships and with far greater flexibility and energy than a traditional corporate enterprise. Especially in a diverse, multi-faceted, and rapidly evolving economic environment, the Commonwealth's capacity for networked entrepreneurship has emerged as a critical competitive factor.[11]

Knowledge-based enterprises thrive on contact with people and ideas outside the organization. They form partnerships with other firms, especially in R&D and marketing. They turn to outside providers for critical services, such as financial, managerial and legal services, employee training, PR, marketing, manufacturing, and logistics. They rely on contributions from key employees with the right skill set and maturity, and who must often be treated as partners, not employees. And they swap information, even with competitors, about everything from promising new technologies to effective ways to compensate their employees.

Such partners, service providers, employees, and information sources must often be geographically proximate. In this context, two types of clustering in knowledge-based economies emerge:

Industry clusters - As Michael Porter and others observed, many of today's most vibrant economies are built around concentrations of firms that compete in the same or related industries. The concentration of computer makers along Route 128 is a fine example. This clustering creates various proximity-based "agglomeration" economies. It aggregates demand for industry-specific resources – for workers with particular skills and suppliers of specialized instruments, materials, and services – and this aggregation of demand serves to attract and expand the

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[10] Robert Forrant, Philip Moss, and Chris Tilly, *Knowledge Sector Powerhouse* (Boston: Donahue Institute, University of Massachusetts, 2001). A striking trend in the '90s was the convergence of earnings in Massachusetts and those in the nation for workers with the same educational attainment. Aside from Massachusetts workers with high school diplomas, who continue to earn significantly more – fifteen percent more – than their counterparts in the nation, earnings in the Commonwealth are only three to five percent greater than those in the nation. Andrew Sum, Mykhaylo Trubb'sky, Neeta Fogg, and Shiela Palma, *The Annual Earnings of Workers in Massachusetts and the United States: An Assessment of Trends in the Level and Distribution of Earnings Over the 1979-2000 Period* (Boston: Center For Labor Market Studies, December 2001).

[11] For discussions of networks, see Walter W. Powell and Laurel Smith-Doerr, "Networks and Economic Life," in Neil J. Smesler and Richard Swedberg (eds) *The Handbook of Economic Sociology*, (Princeton, NJ: Princeton University Press, 1994) and Stuart A Rosenfeld, *Backing into Clusters: Retrofitting Public Policies*, a report to the Organization for Economic Cooperation and Development, 2001, and *Networks and Clusters: The Yin and Yang of Rural Development*, a report to the Federal Reserve Bank of Kansas City, 2001.

supply of these critical inputs. Competition within these clusters also limits the ability of any large player to exploit their suppliers or customers. More critically, this competition stimulates innovation and the rapid diffusion of new ideas, which makes the entire cluster more competitive.[12]

Urban clusters - Knowledge-based firms tend to locate in metropolitan areas to take advantage of two important resources: first - large and expansive assets, like airports and universities; second - rich supplies of sophisticated business support services, including venture capital and other forms of finance; various types of legal, advertising, and marketing services; logistical services for different types of products; hotel, restaurant, convention, and meeting facilities; printing; and office, R&D, and manufacturing space.[13] Two industries that grew rapidly in the 1990s were "business services" and "personnel supply" – "urban" providers of labor shared among firms in many different industries. Robust transportation networks expand the reach of urban economies. In the 1990s, the rapidly developing Interstate 495 belt created a reciprocal flow of knowledge workers and urban assets and linked the resources of the Boston metropolitan area to many smaller Massachusetts cities and towns.

Factor 3: Globalization - The greatest opportunities for a knowledge-based economy lie within the expanding global marketplace. The United States is exceptionally well endowed with highly educated workers compared to other parts of the world, which is why U.S. merchandise exports are heavily weighted toward sophisticated high-tech products. Current research highlights the significance of globalization to the Massachusetts economy:[14]

Manufacturing - U.S. merchandise exports attributed to Massachusetts equaled 35 percent of manufacturing value added in the Commonwealth – the 11th highest level in the nation.

Services - While State-level service export data does not exist, U.S. service exports have been growing rapidly and in 2001, equaled 39 percent of total U.S. merchandise exports.[15] Most prominent are IT services, such as software and systems integration; financial services, such as currency trading, banking, and investment management; higher education, in the form of payments by foreign students studying in the United States; and R&D, in the form of contracts, royalties, and licensing fees. Massachusetts probably captures a disproportionate share of these major knowledge-based exports. The largest U.S. service export, accounting for more than half the total, is Travel and Tourism. The combination of travel associated with merchandise and service exports, plus the Commonwealth's appeal to overseas tourists, made Massachusetts the eighth most popular U.S. destination for foreigners.

Intra-company trade and investment - Sales by foreign affiliates of U.S. companies in 1995 totaled $1.6 trillion – *twice* as large as aggregate U.S. exports. These sales are especially important in the Information Technology (IT) sector, as hardware can often be manufactured more effectively abroad and overseas customers require local marketing, sales, installation, and support services. This international business pattern generates managerial and technical jobs at parent firms, stabilizes the business, and makes the entire enterprise more competitive. Massachusetts also receives significant foreign direct investment, largely through engineering and marketing affiliates of high-tech companies. This strengthens the Commonwealth as a significant node in the global exchange of technical and commercial ideas and stimulates learning and innovation.

Factor 4: The Increasing Importance of "Place" - Knowledge workers are employed in urban and industry clusters that compete in the global marketplace. But they live in local communities. For highly educated workers, these communities are increasingly not where they were born and raised. Most leave home to go to college and move again to attend professional school or to take an attractive first job. Such workers increasingly live where they chose. As a result, living costs and residential amenities have become critical competitive factors controlling the ability of a knowledge-based economy to grow.

Commentators have long argued that the high cost of living in the Commonwealth, and especially the high cost of the housing in Greater Boston, has dampened our competitive success. But as research demonstrates, environmental quality and lifestyle amenities are becoming more critical than living costs in attracting and retaining young knowledge workers.[16] Outdoor recreational activities and a university ambiance often have more appeal than professional sports teams or "high art" museums and symphonies. While the Commonwealth offers many of these traditional amenities, it gets especially high marks for these newer "quality of life" measures.

[12] See Michael Piore and Charles Sabel, *The Second Industrial Divide* (New York, Basic Books, 1984) and Michael Porter, *The Competitive Advantage of Nations* (New York: Free Press, 1990).
[13] Jane Jacobs, *The Economy of Cities* (New York: Random House, 1969), and *The Death and Life of Great American Cities* (New York: Random House, 1961); Edward Glaeser, "Cities, Information, and Economic Growth," *Cityscape: A Journal of Policy Development and Research* 1:1 (1994), "The New Economics of Urban and Regional Growth," in *The Oxford Handbook of Economic Geography*, eds., Gordon L. Clark, Maryann P. Feldman, and Meric S. Gertler, (Oxford: Oxford University Press, 2000).
[14] Jane Little, "Massachusetts: A Neglected 'Global' State," Massachusetts Benchmarks, Summer, 1998.
[15] U.S. Department of Commerce, International Trade Administration. See their web site:.http://www.ita.doc.gov/td/industry/otea/usfth/aggregate/H01t01.html
[16] Richard Florida, *Competing in the Age of Talent*, report prepared for the R.K Mellon Foundation, Heinz Endowments, and Sustainable Pittsburgh, January 2000.

The Dynamics of the New Economy

To get a better understanding of the new dynamics of economic development, we turn to case studies of three Massachusetts industries: biotechnology, Information Technology (IT), and plastics. In analyzing these three industry clusters, we wish to illustrate the influences of the four key competitive factors noted above and highlight their importance to the future of the Massachusetts economy.

The *Massachusetts biotech industry* in the 1990s illustrates the emergence of a classic knowledge-based industry cluster. As one of the Commonwealth's major recipients of federal R&D funding, and with extremely close ties to our universities, biotech also illustrates the larger economic contributions of government and academia in knowledge-based economies.

The evolution of the *Massachusetts IT industry* in the 1990s illustrates the dynamics of a mature knowledge-based cluster – one no longer as dependent on government and university support as biotech. Even after the decline of the minicomputer, the Massachusetts IT cluster remained vibrant because it was a key capital goods industry of the new knowledge-based economy (the other being the higher education, which creates "human capital.") and it had the flexibility to respond to emerging technical and business opportunities.

The *Massachusetts plastics industry* illustrates the dynamics of the Commonwealth's traditional industries in the 1990s. The knowledge-based economy developed new industries, such as IT and biotech, centered largely in Greater Boston. Plastics, centered in the North Central region, was among the Commonwealth's most successful traditional industries during the 1990s. It nevertheless illustrates both the struggles of the State's older industries and regions, and the opportunities smaller businesses have to take advantage of the new opportunities presented by the knowledge-based economy.

The Dynamics of Biotech: The Classic Industry Cluster Model

The rise of the Massachusetts biotech industry illustrates many of the key characteristics of our new knowledge-based clusters. The story begins with the emergence of new technologies in academic laboratories. The new technology, for analyzing and manipulating DNA, has tremendous promise, especially for the enormously high-value pharmaceutical industry. Massachusetts had never been a major player in pharmaceuticals and even today does not rank among the industry leaders in terms of employment. But the new breakthroughs in human genome research place Massachusetts at the innovative frontier of the industry.

The impetus of our biotech cluster – like the defense and minicomputer clusters of the past – has been federal R&D funding. In the 1980s, as the promise of the new technologies came into focus, the National Institutes of Health (NIH) began investing huge sums of money to solve the mysteries of the genome. Massachusetts universities and teaching hospitals were the primary recipients. The Commonwealth received far more NIH funding than any other state in the nation, with annual expenditures estimated at over $1 billion.[17] (see sidebar, *Biotech: A Classic, Knowledge-based Cluster* on right)

This tremendous flow of federal funds created a rich supply of ideas and highly trained workers in our academic institutions. But unlike the case of defense and computers, NIH funding has focused on basic research rather than applied research or development. Unlike the defense industry, the federal government is not "the customer" of biotech products and, as such, does not rely on an entrenched contractor network to manage the transfer of technology from the lab to the marketplace.

Nor have the major pharmaceutical corporations simply hired well-trained Ph.D.s into their research labs elsewhere in the nation. Biotech represents a major discontinuity in the technology of drug discovery. As such, it proved extremely difficult to package and ship the technology to the existing pharmaceutical industry. This was the case despite efforts to encourage such transfers including: a patent system that allowed new biotech discoveries to become negotiable "intellectual property;" the landmark Bayh-Dole Act of 1980 that allowed universities and researchers to claim such negotiable property rights on the fruits of federally funded research; and initiatives by leading Massachusetts universities in establishing units such as MIT's highly regarded Industrial Liaison program to accelerate this transfer of technology. There is a great deal of critical "tacit knowledge" involved in any technology. In Massachusetts, academic centers became prime repositories of this fundamental technical resource. Shared, implied knowledge in these settings inform the perceptions of researchers and decisions advancing technology development.

The actual process of technical innovation – of using biotech to bring valuable new products to market – has been eased by leaner, more nimble entrepreneurial networks. Compared to their governmental and corporate counterparts, these entrepreneurial networks are far richer, more fluid, and diffuse, though often much harder to navigate.

The process begins when university professors, or people with close ties to university labs, establish companies around particular lines of research. Biotech, however, is enormously capital intensive. It requires sophisticated equipment and significant amounts of

[17] Massachusetts Biotech Council *Bionotes*, Fall 2001.

Biotech: A Classic, Knowledge-based Cluster

Biotech illustrates the classic agglomeration economies in knowledge-based clusters. The scale and vibrancy of the industry supports specialized suppliers such as:

- A sophisticated organization – the Massachusetts Biotech Council (MBC) – that organizes symposia, investor conferences, trade expositions, and consular contacts. The MBC supports over a dozen member-directed committees on topics ranging from biostatistics, bioinformatics, and clinical trials to finance and marketing. It even hosts an annual CEO get together , as well as an annual golf outing, which are explicitly designed to expand professional and business contacts.[18]
- Specialized training programs that serve many firms in the industry. The Massachusetts Biotech Council itself sponsors customized training programs for biotech managers in areas such as human resources, finance, and marketing. The University of Massachusetts has established a multi-campus joint Master of Science and Ph.D. degree program in Biomedical Engineering and Biotechnology. Other organizations offering specialized training include Roxbury Community College, which offers a biomanufacturing certificate program, and Boston University, which has developed a graduate program in bioinformatics.
- Specialized real estate developers that convert multi-story brick factory buildings into desirable biotech space. These buildings often have limited commercial value. But their heavy beams can support lab equipment and rooftop mechanicals and their high ceilings can accommodate essential ventilation ducts. Because there is sufficient demand, renovation specialists emerged to develop these spaces. The City of Cambridge drafted regulatory codes and procedures – which other cities and towns have adopted.
- A community of lawyers, venture capitalists, public relations and advertising professionals that specialize in biotechnology. The MBC estimates that at least ten major law firms in the Commonwealth offer the complete range of services a biotechnology company needs, such as negotiating deals, preparing contracts, handling intellectual property claims, and representing the firm in FDA regulatory matters.
- Specialists who can help firms navigate the FDA's precise and complicated approval process. Massachusetts biotechnology companies now have about 40 drugs in clinical trials and more are in the pipeline. These firms need help not just from lawyers, but from experts who know how to manage the trials, maintain proper documentation, and control quality in their manufacturing process.

figure 2–9

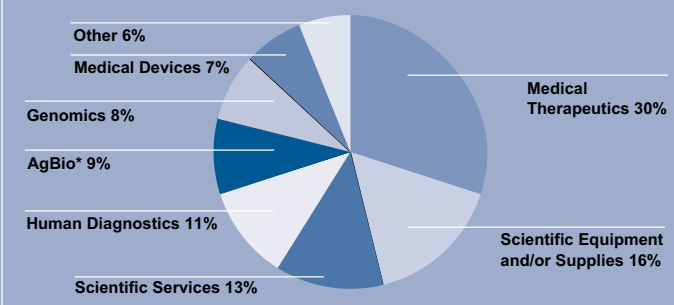
Geogrpaphic Distribution of Biotech Firms in MA

Region	Number	Share
Inside I-95	143	60%
Between I-95 and I-495	68	28%
Outside I495	29	12%
Total	240	100%

Source: Massachusetts Biotechnology Directory 2000, Massachusetts Biotechnology Council

figure 2–10

Biotech Firms Compete in a Wide Variety of Markets



*AgBio includes new strains of plant/animal species and new/enhanced food products.

Source: Massachusetts Biotechnology Council, 2001

[18] The following material comes from the Massachusetts Biotech Council Directory, various issues of *Bioline*, and a conversation with Janice Borque and Stephen Mulloney of the MBC.

time before products come to market. In the case of pharmaceuticals, product development takes a decade or more and can cost hundreds of millions of dollars (see sidebar *The Vibrancy of the Massachusetts "Innovation System"* on pages 25 and 26). These biotech entrepreneurs were able to find funds for their ventures from two main sources – venture capitalists (VCs) and major pharmaceutical companies. Big Pharma, which includes many foreign firms, typically funds specific drug-discovery projects in exchange for marketing rights or similar claims on the results of the project. The VCs typically take an equity stake and they fund a broader set of biotechs, including companies developing tools, information, and services, as well as new pharmaceuticals. Both the VCs and the large pharmaceutical firms typically hold portfolios of high-risk biotech investments[19] and are pleased if any of these investments produce the "the next big thing."

These networked relationships have helped to generate dramatic growth in the Massachusetts biotech cluster. Employment has more than tripled over the decade, from 8,000 workers in 1991 to 28,000[20] in 2001. The number of companies grew just as fast, rising from 88 (1991) to 300 (2000), and they now have a market capitalization of $29 billion. By some accounts, Massachusetts now has the largest concentration of biotech firms in the nation. The cluster is also highly diversified, with firms competing in many different markets. Individual companies are also diversified, competing in more than one biotech market. And this cluster also includes a rich variety of highly-specialized suppliers.

The biotech cluster has benefited from the agglomeration economies provided by the metropolitan Boston economy:

- Because biotech is unusually reliant on networked entrepreneurship, it needs restaurants, conference facilities, and efficient ground transportation. The Massachusetts Turnpike, for example, connects the UMass Medical Center and biotechnology companies in Worcester to the heart of the Boston-Cambridge biotech district, thereby expanding the depth and breadth of the industry cluster.
- Because biotech is a global business with global as well as local networks, it relies on local hotels and taxis, easy access to and from Logan airport, and ample air service to other centers of biotech, finance, and pharmaceutical activity.
- Because many promising opportunities emerge at the boundaries of a particular industry cluster, Massachusetts biotech firms have benefited from links to other powerful clusters in the Commonwealth. Perhaps most important is the recent emergence of bioinformatics. The biotech industry has developed tools that generate mountains of data on microbiological structures and processes. By linking up with powerful IT and computational resources in the Commonwealth, firms can efficiently analyze and manage this data to better understand the underlying biology.

The Dynamics of Information Technology (IT): Continuous Cluster Mobility

The rapid decline of the Massachusetts minicomputer industry at the beginning of the 1990s was a major shock to our economy. The industry had emerged in the 1950s and 1960s and looked much like biotech today – first flush with federal R&D support and university connections, then VC funding and a move into commercial markets. Digital Equipment Corporation (DEC) grew directly out of a major military-funded project at M.I.T. and was the first great success story of the nation's pioneer VC fund – American Research and Development - headed by Harvard Business School professor General George F. Doriot. Soon, other Massachusetts companies entered the field, such as Wang, Data General, Prime, and Apollo. In part spurred on by intense local rivalries, DEC grew to contend with IBM for leadership of the global computer market, and in 1988 employed more than 120,000 workers worldwide.[21]

The minicomputer crash just a few years later was a painful defeat. But it did not mark the end of IT in Massachusetts. The minicomputer companies continued to support old customers and sell new products and services – though at a much reduced rate. More importantly, the crash precipitated a redistribution of the industry's resources into different segments of the broader IT cluster.

The fall of the minicomputer is generally traced to the rise of the personal computer (PC). The 1990s, however, did not become "the decade of the PC." It became the decade of IT networks - from corporate client-server systems to the Internet. Massachusetts had the resources – and the resourcefulness – to succeed on this new innovative frontier.

Distributed computing, a forerunner of modern networking, had actually been an important component of the minicomputer model. Much of our the defense work that took place in Massachusetts, including the air defense project that led to the creation of DEC, involved IT command and control of dispersed weapon systems. AT&T (later Lucent) had a large manufacturing facility in North Andover that became a major provider of communications networking hardware. In essence, the Commonwealth's IT managers and professionals had skills that were applicable far beyond the minicomputer and the firms that produced them.[22]

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[19] Walter W. Powell and Laurel Smith-Doerr provide a glimpse of this complexity taken from their research in the field. Powell and Smith-Doerr, "Networks and Economic Life," p.395 n.15

[20] Massachusetts Biotechnology Directory 2001, Massachusetts Biotechnology Council

[21] Browne and Sass, "The Transition to a Knowledge-based Economy."

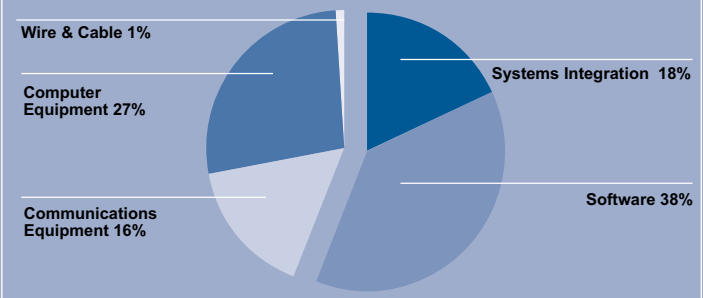
The Massachusetts IT Export Sector Shifts Sharply Toward Software and Systems Integration

As VC investment in the Commonwealth surged in the '90s, the share flowing to the IT sector (defined as communications, software, and semiconductors) slipped from 54 to 47 percent of the total. Attractive opportunities emerged in new areas, such as biotech, and the rapid rise of investment funds pushed VCs to seek opportunities in new areas. Within IT, however, VC funds moved sharply toward "computer software and services" and away from hardware, especially "computer hardware."

By 1998, IT services accounted for over half of total employment in the Massachusetts IT export sector. Computer manufacturing accounted for only one in four IT export-sector jobs.

figure 2–11

By 1998, IT Services Accounted for over Half of All IT Export Jobs



Share All IT Jobs Supporting Export Sales Second Quarter 1998

Source: Craig Moore, "Information Technology: The New Foundation." Massachusetts Benchmarks, Fall 1998. Pg. 21

Over the course of the decade, the high-value activities within the IT industry shifted from computers to semiconductors and communications, from hardware to software, Internet service provision, and content development, and to "enterprise" information systems. Massachusetts IT managers and professionals, many from the minicomputer industry, soon developed exciting new technologies and commercial applications in these areas. Their innovations often involved significant discontinuities in markets, distribution channels, business models, and technical traditions. This required the creation of new firms - even new occupations. The Commonwealth, however, was an unusually fertile ground for developing such ventures because it had:

- The necessary "urban cluster" resources – supporting lawyers, VCs, and marketers, and top-tier education and training, transportation and communications, and hotel, conference, and convention facilities.
- The classic "industry cluster" resources – large numbers of highly skilled people, specialized suppliers, sophisticated customers, and networking organizations such as the Massachusetts High-Tech, Telecommunications, and Software and Internet Councils.
- A unique "cluster" resource – a large concentration of people called "influencers," – the industry analysts, journalists, consultants, and academics who sort through business and technology trends and provide leadership for the global IT sector. Being close to "the conversation" about emerging directions has been a critical advantage in this rapidly changing, multi-faceted sector.[23]

The Massachusetts IT export sector branched out in many different directions and by the end of the decade employed 100,000 people. It stretched across computers and communications, materials, components, and software development, systems integration, content delivery, and the provision of ongoing service and support. As seen in the flow of VC funds and IT employment, software and systems integration – two service industries – emerged as most important. Together they absorbed over half of VC investment and employment in the Commonwealth's IT export sector[24] (see sidebar above, *The Massachusetts IT Export Sector Shifts Sharply Toward Software and Systems Integration Services*).

The Commonwealth's software and systems integration industries follow the knowledge-based economy model. They rely on highly educated workers organized in small firms that depend on networked entrepreneurship. Sixty percent of all Massachusetts software firms employ four or fewer workers; nearly 40 percent are three years old or less. Only five Massachusetts systems integration firms have more than 500 workers and one quarter are three years old or less.[25]

What makes the software and systems integration industries so fluid and dynamic is the fact that capital requirements are low and not highly specialized. These industries use standard office space, which can be rented; PCs, which are inexpensive; and "smart people." Biotech, by contrast, needs costly, industry-specific assets and skills and very patient investors. So in IT, there are many more firms and much more self-employment.

The firms that populate the Massachusetts IT service sector are "machine-shops" for the new global knowledge-based economy.

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[22] Craig Moore, "Information Technology: The New Foundation," *Massachusetts Benchmarks*, Fall '98.

[23] This observation and the term "influencer" comes from Joyce Plotkin, President of the Massachusetts Software and Internet Council.

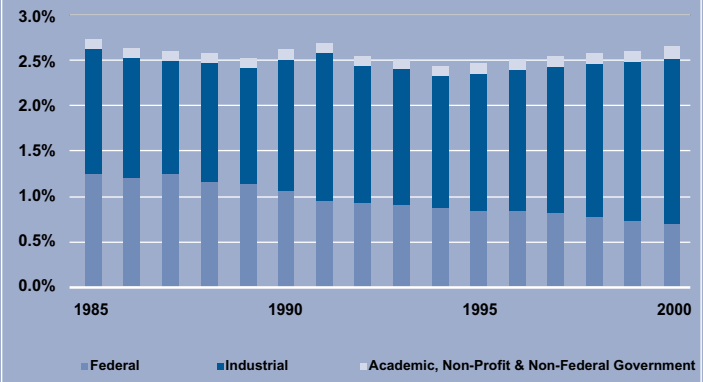
[24] Craig Moore, "Information Technology: The New Foundation." 1998.

[25] Ibid.

While funding for research and development remains steady, industry increases its share of investment

figure 2–12

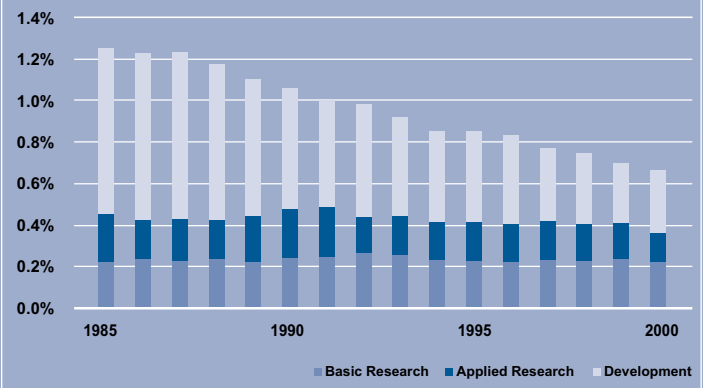
Total R&D % GDP by Source of Funds



Source: National Science Foundation, as reported by the Massachusetts Technology Collaborative

figure 2-13

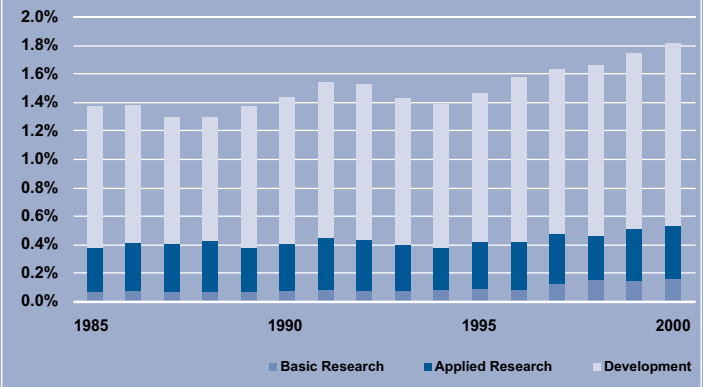
Federal R&D % GDP by Character of Work



Source: National Science Foundation, as reported by the Massachusetts Technology Collaborative

figure 2-14

Industrial R&D % GDP by Character of Work



Source: National Science Foundation, as reported by the Massachusetts Technology Collaborative

The Vibrancy of the Massachusetts "Innovation System"

R&D expenditures are the lifeblood of the technical innovation process. In the U.S., R&D investments over the past half-century have consistently been 2.5-2.8 percent of GDP. The allocation of this investment into basic research, applied research, and development has also been relatively stable. What changed dramatically over the previous decade has been the decline of federal spending, its concentration on "basic research," and the rise of industry investment in "applied research" and "development."

Massachusetts has long received far more federal R&D funding per capita than any other state in the nation, giving the Commonwealth a critical foundation for technical innovation. As competition for federal R&D funds intensified in the 1990s, the State's share of federal expenditures declined. Far more dramatic was the shift in the Commonwealth's portfolio of federally funded R&D from strength in two sectors -- defense and life sciences – to strength in the life sciences alone. Consistent with this shift away from defense, and with the government's shift toward basic research, the flow of federal R&D funds into Massachusetts has moved from industry and defense-related labs to our universities and hospitals.

Corporations and individual entrepreneurs have thus assumed primary responsibility for "applied research" and "development" – for bringing technically sophisticated goods and services to market. Our major universities have supported these efforts by setting up offices for transferring academic technology and intellectual property out of the labs and by encouraging faculty to develop relationships with the commercial sector. The two main sources of private funds for the commercialization of new technologies are major corporations and venture capitalists (VCs). The VCs are especially important. They generally look to grow the business to the point where they can "exit" investments through an initial public offering or by selling out to a larger firm. In addition to providing funds, VCs help technical entrepreneurs target promising market segments and identify what customers want; develop a viable business model; and negotiate complex deals with banks, corporate partners, and providers of business services.

Venture capital investments fuel growth and innovation

figure 2–15

The boom and bust in venture capital spending in select markets

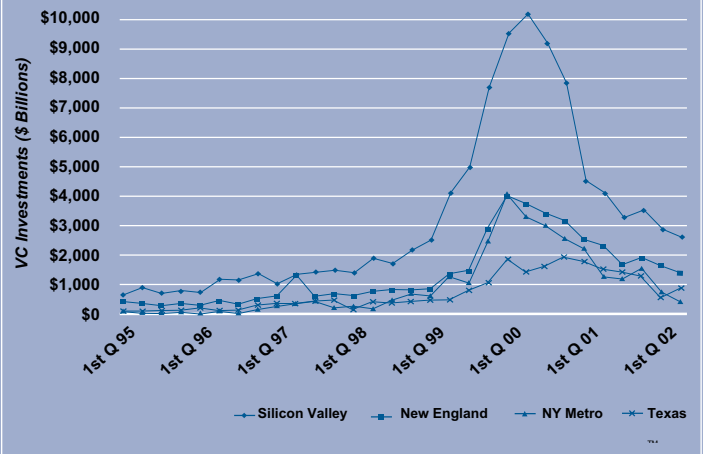
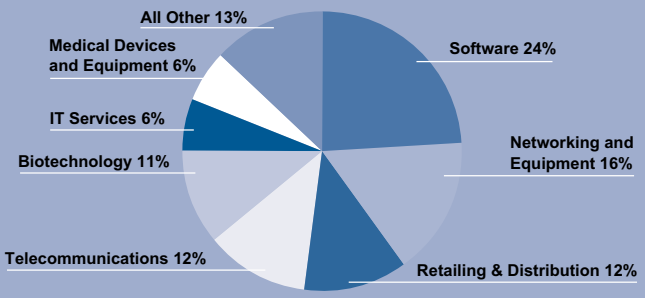


figure 2–16

Distribution of venture capital investments in Massachusetts, 2001



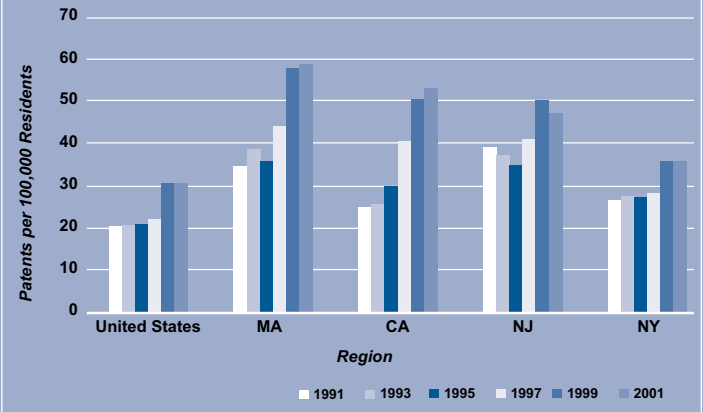
Source: PricewaterhouseCoopers/Venture One, as reported by the Massachusetts Technology Collaborative

Over the past decade, Massachusetts has attracted about ten percent of total VC investment in the United States, an extraordinary sum in per capita terms. This funding vehicle helped Massachusetts remain a leader in patent awards and generated a large number of "gazelles" – publicly traded companies that grow twenty percent or more per annum for four years running. VC funding boomed in the late 1990s, and peaked in fiscal 2000, clearly an aberrant year. Firms located in the Commonwealth secured $8.8 billion in venture funding in 2000 which exceeded $3 billion in the first quarter alone. VC investment has since fallen significantly. As a result, technical entrepreneurs have had to seek corporate sponsorship or scramble to find ways to increase cash flows from operations.

Increased private investment encourages entrepreneurs

figure 2-17

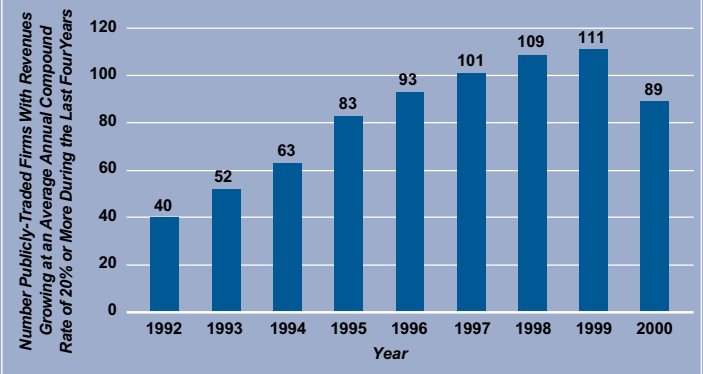
Massachusetts is the national leader in patents per capita



Source: US Patent and Trademark Office

figure 2-18

The number of "Gazelle" firms increased during the 1990s



Source: Standard & Poors Compustat, as reported by the Massachusetts Technology Collaborative

IT is now the fundamental tool of educated workers in business and the professions worldwide. It requires an enormous amount of intense, creative effort to fit these tools for the job. Massachusetts firms thus develop software components and tool kits in areas ranging from graphics, networking, and data management to "vertical" solutions for particular industries or professions.

Nearly every business and professional group now relies on a community of software and systems integration specialists to support their particular IT needs. These service providers often become intimately connected with these businesses and professions and their activities often cross over to adjacent IT activities. They move from software into systems integration or consulting; or augment a web-service venture by developing content or adding a critical software application. They also move into their client's industries as well. The emergence of bioinformatics on the boundary between IT and biotech is typical. Interestingly, the Massachusetts Biotech and Software and Internet Councils both identify bioinformatics as a major opportunity for their respective industries. In knowledge-based economies, the most powerful "knowledge spillovers" often flow across industry lines in this way (see sidebar, *The Massachusetts IT Export Sector Shifts*, on page 24).

The lesson from the IT cluster, and the rise of the Internet in particular, is that innovation is an incredibly dynamic process. The underlying technologies and business models are continually evolving, dividing, and merging. Knowledge-based economies must be analyzed over time rather than at a particular moment. Thus, the Massachusetts minicomputer industry of the 1980s is best seen as a powerful convergence of technical and economic resources in a larger economic stream. It held together for about two decades, then came undone in the early 1990s. Those resources flowed into succeeding computer architectures, and out into communications, systems integration, software, Internet development, and other new dynamic industries within the IT sector as well as along its fuzzy borders. The recent sharp drops in demand in the Internet and telecom businesses foreshadow another economic cycle of adaptation and diffusion.

The Dynamics of Plastics: Leveraging Traditional Industries

Plastics was among the Commonwealth's most successful "traditional" manufacturing industries in the 1990s. While essentially all Massachusetts manufacturing industries lost jobs during the decade and overall manufacturing employment fell more than fifteen percent, business in plastics was brisk and employment rose by more than ten percent.[26]

Plastics is "traditional" in that the industry relies on more typical "shop floor" manufacturing and is dominated by small, locally owned firms, primarily in the central and western parts of the State. They typically employ up to 45 employees, mostly on the shop floor. Approximately 700 such companies in the Commonwealth make a wide range of products, which can be grouped into three main categories: 1) packaging, such as plastic bags and packing materials; 2) high-volume commodity items, such as pails, cosmetic tubes, and disposable cutlery; and 3) specialty products, such as parts for aircraft, automobiles, medical devices, computers, and telephones. Also considered "traditional" are the economic advantages and challenges facing Massachusetts plastics manufacturers:[27]

• **The industry's main competitive advantage** is the quality of employee metalworking skills in the Commonwealth. Plastics manufacturers generally use injection-molding machines that need precision molds for efficient production and to make a premium product. Thus, the pieces from different Lego® sets snap together cleanly because they were all made from high-quality precision molds. Mold making is a branch of tool and die making, a well-known Massachusetts manufacturing skill set. While precision molds are important in all branches of the industry, they are critical in the production of specialty parts for other manufacturers.

• **The industry's main competitive disadvantages** are a lack of adequate space and the high cost of energy and transportation. The industry needs modern one-story buildings with good rail, road, water, sewer, gas, and electric connections. Such space is in short supply and vacancy rates in Leominster, the center of the Massachusetts plastics industry, fell below five percent at various points during the 1990s. Energy and transportation costs in the Commonwealth are relatively high and represent a significant percentage of total production costs. As a result, Massachusetts manufacturers primarily sell to customers in the New England and Mid-Atlantic states. While there was a flurry of interest in overseas markets in the early 1990s, exports remain less than ten percent of total industry sales.

What differentiated plastics from other traditional Massachusetts manufacturing industries was a sharp increase in product demand, not a dramatic shift in productivity. The industry did not suddenly become more competitive than other traditional Massachusetts manufacturers. Instead, it benefited from a major increase in the use of plastics, for items such as bottles and auto parts, and from a surge in sales of items such as computer wiring and cabling and shells for phones, laptops, and other types of office equipment.

As in most other traditional Massachusetts industries, the knowledge-based economy had a very different impact on plastics than it did on the biotech or IT industries. A survey of manufacturers in the North Central region found little contact with the Commonwealth's top-tier academic plastics programs at UMass Amherst and UMass Lowell. Nor did these manufacturers see much value in developing a local plastics technology center.

Manufacturers did, however, identify worker training as their primary need. Skilled mold-makers have been in short supply since the demise of apprenticeship programs in the 1960s and 1970s. Today's mold-makers need training in CAD-CAM programs, an important upgrading challenge for firms and workers, as well as in traditional mechanical skills. Workers who operate modern computerized injection molding machines also need training to set up, monitor, and maintain the equipment. As Asian and Hispanic immigrants now make up one quarter of the workforce, the industry also needs remedial English as a second language (ESL) programs.[28]

Raising the level of workforce skills has been difficult. The problem is a lack of utilization, not of programs. Institutions such as the Center for Technical Education at Leominster High School and Mount Wachusett Community College offer highly regarded instruction. But many companies in the industry are small. They don't have the management resources necessary to stay abreast of current offerings or to get their workers involved. There is also a "market failure" dilemma: Workers who get trained capture the bulk of the benefits in the form of higher market wages. So employers have little financial incentive to pay for the training. Workers, on the other hand, often lack the time and funds to pay for the programs. Many are also unwilling to bear the risk that the investment of time and money will not lead to a better job and higher pay.

Although the knowledge-based model has not penetrated very deeply among the Commonwealth's plastics manufacturers, three ventures illustrate its potential to transform traditional Massachusetts industries:

• Ongoing efforts by local business and government to strengthen the industry cluster and to develop networking opportunities. This includes efforts to improve rail service and lower electricity rates and the organization of massPlastics, a major tradeshow held every 18 months in Fitchburg. The City of Leominster and the local Chamber of Commerce have also collaborated on various initiatives to rationalize worker-training programs and provide access to UMass faculty at Amherst and Lowell.

• Plastics.com, based in Fitchburg, is a Web portal created by Greg Koski, a UMass-Lowell-trained plastics engineer with extensive experience in management and communications. The site is a networking initiative that targets "plastics professionals" ("professionals being a more elegant name for "knowledge workers"). It promises "the ultimate peer-to-peer experience, providing actionable information, tools, and services to help members get their jobs done." The site offers technical and business information, online training and "forums" for discussing specific technical or business issues, a service connecting manufacturers and customers, and a marketplace for buying and selling new and used equipment.

• Nypro, based in Clinton, has emerged as an enormously successful knowledge-based plastics manufacturer with $500 million in sales and plants in a dozen countries around the globe. The company has extended its value proposition far beyond molding to offer "complete product outsourcing" – integrating backward into product design and forward into product assembly. It uses sophisticated IT systems for supply-chain management and to keep its customers and far-flung operations continually in the loop. Clinton houses the company's headquarters, its product design and development center, one of two precision mold-making centers, a substantial molding facility, and its innovative educational initiatives –the Nypro Institute and Nypro Online. The Institute is Nypro's corporate training center and works with colleges around the world to offer English language and high-school equivalency instruction, as well as undergraduate and graduate programs in business and engineering subjects. Nypro Online, run in conjunction with UMass-Lowell offers college-level courses in plastics engineering and a certificate in plastics technology to the entire industry. For such efforts, Nypro won the 2001 University of Massachusetts Employee Education Circle of Distinction Award.[29]

Challenges Moving Forward

These three case studies illustrate the new dynamics of economic development at the industry cluster level. They highlight the importance of the four underlying factors identified above and their contribution to the Commonwealth's generally successful response to the sharp downturn of the early 1990s. They also underscore our primary economic challenges going forward:

1. **Knowledge workers** –clearly the most important resource in the "new" Massachusetts economy.
2. **Networked entrepreneurship** – the primary means for mobilizing resources in industry or urban clusters.
3. **Globalization** – which has profoundly reconfigured market opportunities and the competitive environment.
4. **Quality of "place"** –the quality of life in our communities is not just an ultimate economic objective, but is now a critical factor in the global competition for knowledge workers and knowledge-based industries.

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[26] The percent change figure for employment in plastics is taken from CES 790 data for SIC 308 – "Miscellaneous Plastics Products." http://www.detma.org/lmi/dataprog.htm.

[27] This section relies on an interview with Todd Shimkus, Vice President of the North Central Chamber of Commerce, and Steven Landau, Steven Ellis, William Ennen, and Robert Forrant's, "Strategies to Support the Plastics Industry in North Central Massachusetts: A Report to the City of Leominster," UMass Donahue Institute, University of Massachusetts, March 2000.

[28] Interview with Todd Shimkus

[29] See the Nypro website, www.nypro.com.

Challenges Moving Forward: Knowledge Workers

Knowledge has become the fundamental instrument of value creation in the New Economy. As such, the Commonwealth devotes an enormous amount of resources to its educational and training programs. The majority of our young people now go to college and a good portion will spend nearly twenty years in school. Periodic training to upgrade one's skills is now routine for lawyers and physicians as well as shop floor workers. And the returns to these investments have been excellent.

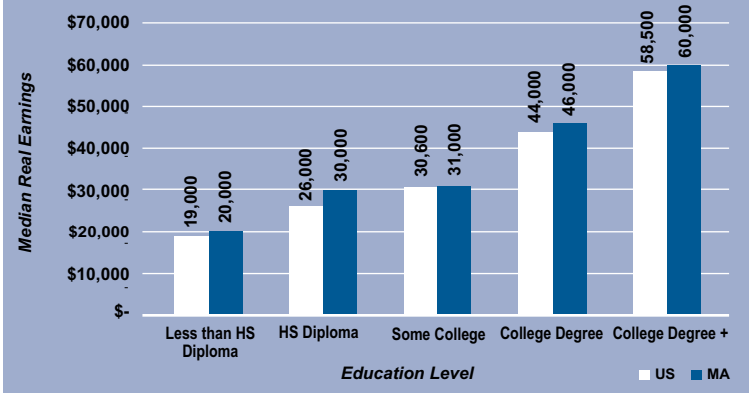
The primary risk going forward is the limited reach of these programs. The 1990s were marked by significant shortages of science, engineering, health care, and education professionals. While the incomes of college-educated workers soared, those without a four-year degree earn little more today than they did in the difficult years at the beginning of the decade.[30]

Expanding access to higher education is one clear response, and the proportion of Massachusetts workers with a college degree rose smartly in the 1990s. Employers in both biotech and plastics would gladly hire production workers without a four-year degree if they had the proper skills. Both groups of employers highlight a serious shortage of workers trained to operate today's sophisticated production equipment. Most workers with a high-school diploma or less find employment not in production, but in service occupations – in hotels and restaurants, medical and nursing facilities, building maintenance and security, and the like.[31] In these occupations as well, training can augment worker skills and lead to greater productivity and income[32] (see figure 2-19).

Our challenge is to develop an education and training system that upgrades the skills and efficiency of our workforce in response to labor market demands. What complicates the task is a serious deficiency in the basic skills needed to compete. One-third of the Massachusetts workforce – 1.1 million Massachusetts workers – lack a high school diploma or GED, speak or write limited English, or have significant deficits in basic verbal or quantitative skills.[33] As the Massachusetts workforce historically grows quite slowly, upgrading the skills and efficiency of current workers is nevertheless the most effective way to provide an adequate supply of knowledgeable workers to a growing economy.

figure 2–19

Education and Knoweldge-Based Skills Are Essential in Today's Economy



A.Sum et al, Earnings of Workers in Massachusets and the United States. MassINC, December 2001.

Challenges Moving Forward: Networked Entrepreneurship

The Commonwealth's urban and industry clusters are incredibly rich in resources, firms, and workers who use a web of local connections to access critical inputs and opportunities. This is "networked entrepreneurship," the focus of AnnaLee Saxenian's book comparing Silicon Valley to Route 128. What Saxenian did not foresee, however, was the flexibility and strength of networked entrepreneurship in Massachusetts. It underlies the successful reorganization of our IT cluster after the fall of the large, vertically integrated minicomputer makers. It also allowed our biotech industry to respond to the precipitous drop in VC funding and turn toward corporate sponsorship – to shift its attention away from building tools and "promise" to focus on concrete drug development.

The primary challenge moving forward is the limited reach of our entrepreneurial networks. Many small firms and workers simply do not have the capacity needed to participate in these networks. As Boston is the center of the State's most vibrant entrepreneurial networks, distance significantly diminishes their usefulness for many firms and workers in the Commonwealth. Even within Boston, race and a lack of proficiency in English can restrict participation. A major consequence of this limited capacity is insufficient access to training and technical assistance, as seen in the plastics industry in the North Central region. Distance from Boston and weak entrepreneurial networks in many industries and regions limits access to capital, especially venture capital, and to technical and informational resources that are abundantly available in the Commonwealth.

Expanding the reach of our entrepreneurial networks is the task of Massachusetts' trade associations, such as the Biotech and Software and Internet Councils; local governments and Chambers of Commerce, such as the plastics initiatives underway in Leominster; and entrepreneurial ventures such as plastics.com. In labor markets, intermediaries such as professional associations, unions, and

[30] Andrew Sum, et al., *The Annual Earnings of Workers in Massachusetts and the United States.*

[31] These occupations are most prevalent among workers with a high-school education or less in the Boston metropolitan area, reports Richard LaRock, research assistant at the Center for Urban and Regional Policy at Northeastern University.

[32] Joan Fitzgerald and Virginia Carlson, "Ladders to a Better Life," *The American Prospect*, June 19-July 3, 2000.

[33] John Comings, Andrew Sum, Johan Uvin, et al., *New Skills for a New Economy: Adult Education's Key Role in Sustaining Economic Growth and Expanding Opportunity* (Boston: MassINC, December, 2000).

social service agencies have also been able to support networks that expand worker productivity and provide access to better jobs.[34]

Maintaining our competitive strength in advanced academic research is an especially critical challenge. Many competing states have adopted a research-led economic development strategy and are investing heavily in university R&D facilities. One indication of their competitive success is Massachusetts' declining share of federal R&D funds. If Massachusetts were to lose this competitive edge, our entrepreneurial networks would lose a key competitive advantage in today's knowledge-based economy.

Challenges Moving Forward: Globalization

Globalization presents enormous opportunities. The knowledge-based goods and services we produce are especially attractive to overseas markets, and overseas sales generate a major portion of the Commonwealth's export earnings.

Globalization also brings new challenges. Massachusetts firms now compete with many powerful, fast-moving high-tech overseas rivals. While most of our traditional manufacturers sell to domestic markets, foreign producers also increasingly offer vigorous competition.

Our most critical challenges, however, increasingly arise from limited access to global markets. Access to these markets is increasingly dependent on access to the Internet. The Web is the new "face" of the marketplace, and it knows no national boundaries. Yet Massachusetts communities and regions lack affordable broadband service. Left unaddressed, this limited access will severely impede their participation in the new world of business.

Another challenge arising from limited globalization is the lack of institutions that can maintain macroeconomic stability. Recent swings in global demand have been large and have exacerbated economic swings in the Commonwealth. Thus, Massachusetts merchandise exports surged by one third in the boom year of 2000, then fell back to their former level in a weak 2001.[35]

Our final challenge is the enhanced need for security. The September 11 attacks damaged the global marketplace, added significant costs to trade and travel, and cut worldwide demand for goods and services provided by our knowledge-based industries. More broadly, as described in *The Lexus and the Olive Tree*, unprecedented mobility and access give individuals the power to shape market outcomes and effect nations.[36] Going forward, we need the means to protect our citizenry and economy from untoward exercise of that power.

Challenges Moving Forward: The Quality of "Place"

Firms and workers have long been attracted by the quality of life in our communities. In this new age of the mobile knowledge worker, it has become a major competitive advantage.

The main challenge moving forward is to ensure that economic development strengthens rather than diminishes our quality of life. Development typically puts pressure on real estate prices, the environment, and existing infrastructure. Thus, in the boom years since 1997, the median price of a single-family home in the Boston metro area doubled to hit $367,000 in 2001.[37] Many citizens of the Commonwealth can no longer translate income gains into home ownership. Real estate development, moreover, has increasingly taken the form of sprawl, which generates pollution, congestion, and a general degradation in the quality of life.

The primary risk moving forward is to accommodate economic development while maintaining and enhancing our quality of place. Rapid economic growth along Interstate 495 highlights the challenge before us. The corridor offers attractive countryside, New England charm, more reasonably priced housing, access to both Boston and vibrant recreational areas, and rapid growth in high-paying jobs. The highway itself, however, runs along the boundaries separating many different watersheds and political jurisdictions. Building new sewers and schools and relieving congestion on the area's roads have emerged as critical economic development issues along the corridor.[38]

The challenge before us is to develop a vibrant knowledge-based economy while preserving critical environmental and quality-of-life assets. We need an infrastructure that responds to the need for knowledgeable workers; that enables networked entrepreneurship throughout the Commonwealth; that gives broad access to the opportunities offered by globalization while effectively responding to its threats; and that strengthens the quality of "place." These are the leverage points of a new strategic framework for economic development. Their identification also highlights the importance of developing new economic objectives for this new economic time.

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[34] See Fitzgerald and Carlson, "Ladders to a Better Life," to see how labor-market intermediaries have organized career ladders for low-paid urban service workers that involve training and certification and the expectation that workers will "hopscotch" up from one employer as they make their way forward. This approach, which parallels the model set in sophisticated knowledge-based industries, demonstrates the importance of education and training throughout the economy. It also underlines the importance of entrepreneurial networks to make such an economy operate effectively.

[35] Merchandise exports are used to track overseas sales because data is available on this component of Massachusetts exports. See the Federal Reserve Bank of Boston's New England Economic Indicators Database, http://www.bos.frb.org/economic/neei/neeidata/totexp.csv

[36] Thomas Friedman (New York: Farrar, Straus, and Giroux, 1999).

[37] http://www.bos.frb.org/economic/neei/neeidata

[38] Sarah Kuhn, "Interstate 495 West," *Massachusetts Benchmarks* Fall 2000.